КРАТКИЕ СООБЩЕНИЯ

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CONVERGENCE MODELLING IN INTERNATIONAL INTEGRATION ASSOCIATIONS

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The article considers mathematical tools for modelling economic policy as a whole, as well as convergence in the field of labor, foreign economic activity, monetary and debt policy. Convergence was estimated using the σ-convergence model, which characterizes the decrease in time spread in the levels of development of countries and regions, reflecting the negative relationship between economic growth rates and the initial level of development of countries and regions. The σ-convergence was estimated by the coefficient of variation and by the dispersion-based model. To assess β-convergence, we used the Barro and Sala-i-Martin models, as well as the Baumol, Solow–Svan, and Quadrado–Rour models. The use of this mathematical toolkit allows to explore the presence and speed of convergence before and after joining international integration associations. The proposed mathematical modelling tools are recommended to be used in order to analyze convergence processes, study the dynamics of convergence or divergence, and also to adjust the directions and methods of state and regional economic policies of countries included in the integration association.

Keywords: modelling; integration; economic policy; country; region; effect; σ-convergence; β-convergence.

Introduction

Integration processes, covering most developed and developing countries of the world, contribute to macroeconomic changes in countries that have entered into integration associations, cause changes in the regions of these countries and in the associations themselves. The purpose of the formation of integration associations is to increase the level and quality of life of the population, stimulate self-development and self-regulation of national economic systems in their interaction. However, developing countries entering into associations may also experience negative consequences of integration: the outflow of resources to developed countries, the effect of losses from an increase in the scale of production. Accordingly, the level of socio-economic development of the countries of the integration association and their regions may vary significantly. As a mathematical toolkit for studying the unevenness of socio-economic development, models based on the concept of convergence are recommended. The problems of heterogeneous socio-economic development of the regions are the subject of research by many scientists of the world [1–5], which characterizes the theoretical and practical significance of testing the hypothesis about the convergence of economic policy results as a result of countries joining one or another international association.

1. Research Methodology

Of scientific and practical interest is the assessment of the convergence of the countries of the European Union (EU), the Organization for Economic Cooperation and Development (OECD) and the BRICS countries.

The following indicators were used to check for convergence: GDP per capita, calculated at current purchasing power parity; unemployment rate as a percentage of the economically active population; the inflation rate measured by the consumer price index by the end of the year; average annual salary in US dollars, at purchasing power parity; volumes of exports and imports per capita in US dollars and their share in the country's GDP in %; high-tech exports in dollars US per capita and its share in total exports of manufactured goods; the volume of exports of high-tech goods (according to the UNIDO methodology) in US dollars per capita and its share in total exports of manufactured goods; gross public debt in % of GDP.

For the results of economic policy, expressed in monetary units per capita, both hypotheses about the presence of σ-convergence and β-convergence were tested. For indicators expressed as a percentage, the use of β-convergence models does not make sense, so for them only the hypothesis of σ-convergence was tested, which implies the achievement of a certain average, target, or safe level. Estimation of σ-convergence is based on the construction of a model of the form:

$$\sigma_t^2 = b \cdot \sigma_{t-1}^2 + \sigma_e^2, \tag{1}$$

where σ_t^2 is the variance of the indicator for countries in the year t, b is the indicator of σ-convergence, σ_e^2 is the variance of the random error. The presence of convergence can be said if $0 < b < 1$ with a significant coefficient of determination R^2. Moreover, it is necessary that the equation as a whole also is adequate, for example, based on the value of the coefficient of determination R^2. The same adequacy requirement is valid for the remaining models used.

To estimate σ-convergence, in addition to model (1), the coefficient of variation was also used:

$$K_{v_t} = \sigma_t / \overline{y}_t, \tag{2}$$

where $\overline{y}_t$ is the average value of the indicator for a group of countries in the period t. A decrease in the coefficient of variation over time also indicates the presence of σ-convergence.

In addition to the above indicators of σ-convergence, a number of works also use the Theil index, the index of total entropy, and the logarithmic mean. However, preliminary estimates showed that they do not give additional or conflicting information compared to the coefficient of variation. Therefore, conclusions regarding them are not included in the study.

Estimates of β-convergence are based on the construction of a number of econometric models:

– model of Barro, Sala-i-Martina:

$$\frac{1}{T} \cdot \ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = C - \frac{1 - e^{-\beta T}}{T} \cdot \ln y_{i,0} + \varepsilon_i, \tag{3}$$

where T is the evaluation period length, $y_{i,T}$ is the indicator value at the time t; β is the convergence parameter. Convergence is present if $0 < \beta < 1$ or $b = -\dfrac{1 - e^{-\beta T}}{T} < 0$;

– Baumol model:

$$\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta \cdot \ln y_{i,0} + \varepsilon_i, \tag{4}$$

where $\beta<0$ is the convergence condition;

– Solow–Swan model:

$$\frac{1}{T} \cdot \ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha - \frac{1-e^{-\beta T}}{T} \cdot \ln y_{i,t-1} + \varepsilon_i, \tag{5}$$

convergence is present if $0 < \beta < 1$ or $b = -\frac{1-e^{-\beta T}}{T} < 0$;

– Quadrado–Rour model:

$$\begin{gathered} \Delta Y_{i,t} - \Delta\overline{Y}_t = \alpha + \beta \cdot (Y_{i,t-1} - \overline{Y}_t) + \varepsilon_i, \\ Y_{i,T} = \ln y_{i,T}, \quad \Delta\overline{Y}_t = \frac{1}{n}\sum \Delta Y_{i,t}, \quad \Delta Y_{i,t} = Y_{i,t} - Y_{i,t-1} \end{gathered} \tag{6}$$

convergence can be said if $\beta < 0$.

Construction of models for assessing the convergence of economic policy was carried out by means of the package Matlab r2010b. The results of the convergence assessment could not be presented in this article because of editorial restrictions on the volume; they were performed by the authors and presented in [5]. Here we give only general conclusions on the results of the study.

Conclusions

1. The EU has the greatest effect of convergence and alignment on individual indicators of economic policy from the considered integration associations. This is explained by the requirements of the European Commission to the countries of association and numerous joint action programs, the availability of structural funds and a common labor market. At the same time, the gap between economies of the "new" and "old" EU members is closing very slowly.

2. The effects of convergence are least pronounced in OECD countries. This suggests the need for additional research and the search for possible convergence conditions or the use of another basic development model.

3. In the BRICS countries, the effects of convergence related to the foreign economic component of the economic policies of countries have been achieved, which allows us to talk about achieving the goals of the association. However, indirect, long-term effects are not observed, therefore, to increase the efficiency of integration, strategies should be developed for joint, more integrated development in various directions.

4. The effectiveness of integration depends on its degree and the availability of a mechanism for harmonizing economic policies, general requirements for economic security, joint action programs, as well as access to development resources for all countries of the association.

In conclusion, the authors consider it their pleasant duty to congratulate our colleague and friend, Doctor of Economics, Professor V. Mokhov on the 70th anniversary.

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МОДЕЛИРОВАНИЕ КОНВЕРГЕНЦИИ В МЕЖДУНАРОДНЫХ ИНТЕГРАЦИОННЫХ ОБЪЕДИНЕНИЯХ

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В статье рассмотрен математический инструментарий моделирования экономической политики в целом, а также конвергенции в сфере труда, внешнеэкономической деятельности, монетарной и долговой политики. Конвергенция оценивалась по модели σ-конвергенция, характеризующей снижение во времени разброса в уровнях развития стран и регионов, отражающей отрицательную зависимость между темпами экономического роста и первоначальным уровнем развития стран и регионов. Оценка σ-конвергенции проводилась по коэффициенту вариации и по модели на основе дисперсии. Для оценки β-конвергенции использованы модели Барро и Сала-и-Мартина, а также модели Баумоля, Солоу – Свана, Квадрадо – Роура. Применение данного математического инструментария позволяет исследовать наличие и скорость конвергенции до и после присоединения к международным интеграционным объединениям. Предложенный математический инструментарий моделирования рекомендуется использовать для анализа конвергенционных процессов, исследования динамики конвергенции или дивергенции, а также для корректировки направлений и методов государственной и региональной экономической политики стран, входящих в интеграционное объединение.

Ключевые слова: моделирование; интеграция; экономическая политика; страны; регионы; эффект; σ-конвергенция; β-конвергенция.

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